

IMPREGNATED BODIES MADE OF EXPANDED GRAPHITE, PROCESS FOR

PRODUCING SUCH BODIES AND SEALING ELEMENTS, FUEL CELL

5 COMPONENTS AND HEAT-CONDUCTING ELEMENTS FORMED OF THE BODIES

Background of the Invention:

Field of the Invention:

10 The invention relates to a synthetic resin-impregnated body
made of expanded or at least partially recompressed expanded
graphite, a process for producing such a body and a sealing
element, a fuel cell component and a heat-conducting element
employing the body. In this context, the term "synthetic
resin-impregnated body" is understood to mean a body made of
15 expanded graphite which is impregnated by synthetic resin.

Material composites of graphite and plastics are widely used
in many technical applications. For example, particles of
electrographite are processed with fluoroplastics into highly
20 corrosion-resistant components for the construction of
chemical apparatus, but they are comparatively expensive due
to the costs of the fluoroplastics and of the processing
technique that is required. A subject which in terms of
content is even closer to the present application is set out
25 in U.S. Patent No. 4,265,952: expanded graphite is mixed, for
example, with fine PTFE powder and subsequently compressed.

To that extent, the production technique differs from the impregnating technique described in the present application.

Another example of a material composite of graphite and plastics material is superficially resin-impregnated foils made of natural graphite, which are predominantly employed in the form of flat seals against particularly aggressive media. Many references to that second example are found in the technical literature.

Today, thousands of tons of foils made of natural graphite are produced worldwide every year. The process used therefor is described in European Patent Application 0 087 489 A1, U.S. Patent No. 3,404,061 and U.S. Patent No. 3,494,382. Those disclosures are incorporated by reference in the present application. The teaching of those references can be summarized as follows: an intercalating agent such as concentrated sulfuric acid, for example, acts on natural graphite, preferably platelike or flaky natural graphite, in the presence of an oxidizing agent such as concentrated nitric acid or hydrogen peroxide, for example. That results in graphite intercalation compounds that are likewise flaky or have a platelike shape. The flakes are thermally decomposed and, as a result of the gas pressure arising in their interior during that decomposition process, puff up to form loose graphite particles with a wormlike shape by brief heating, for

example by introduction into the flame of a gas burner. That product is also referred to as "expanded" graphite or as graphite expandate.

- 5 Expanded graphite is extremely plastic and can be readily shaped without the aid of a special binder while being compressed to a greater or lesser degree. Economically, the most important product thus produced is a flexible graphite foil, which can be produced efficiently on calender belts.
- 10 Such products have typical bulk densities of between 0.7 and 1.3 g/cm³. However, other parts having different geometry, for instance individual sealing bodies which, on average, are compressed to a greater degree and have bulk densities of 1.0 to 1.8 g/cm³, are also possible. There are also sponge-like
- 5 parts, on average having low bulk density, with values of 0.1 to 1.0 g/cm³. All of those bodies with different shapes and different bulk densities have an open pore system. They are referred to hereinbelow as a "primary product".

- 20 Material composites formed of such a primary product and synthetic resins or plastics materials perform a variety of tasks. Synthetic resins or plastics materials lower the permeability, improve the surface properties, for example the scratch resistance, increase the strength to a small extent,
- 25 lower the thermal stability of a material composite containing expanded graphite, and can also reduce the electrical

conductivity or modify the resistance to media. An expedient technique for the production of such material composites is impregnation.

- 5 According to German Patent DE 32 44 595 C2, corresponding to UK Patent Application GB 2 131 500 A, the sticking action of graphite foils to metal surfaces can be reduced by impregnating the primary product with furan resin in regions close to the surface.

10

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2205
2206
2207
2208
2209
2210
2211
2212
2

Another method for achieving good impregnation of bodies made of expanded graphite resides in converting the desired resins through the use of solvents into low-viscosity liquids, whereby the impregnation becomes more complete. In Published
5 Japanese Patent Application JP 11 00 040 A2, the thermosetting resins named are based on phenols, epoxides, polyimides, melamines, polyesters and furans, which are used in a mixture solution with polyvinylbutyral.

10 Published Japanese Patent Application JP 1 308 872 A2 describes the solution to other problems. A material composite formed of a glass fiber nonwoven fabric and an expanded graphite foil is produced in order to thus strengthen the latter and overall obtain a liquid-tight material. That
15 is achieved by impregnating with epoxy resin. The resin penetrates the nonwoven fabric, with the composite material being formed during the subsequent curing of the support part. At the same time, the resin also penetrates into the surface, i.e. partially into the foil, and seals the latter.

20 The impregnation of expanded graphite foil with phenolic resin or epoxy resin, which is set out in Published Japanese Patent Application JP 60 24 2041 A2, corresponding to German Patent DE 35 12 867 C2, serves similar purposes, namely to improve
25 strength and gas-tightness. The special feature in that case lies in a degassing process for the liquid resins and the foil

present therein which is repeated a number of times,
presumably with the aim of improving the quality of the
impregnation.

5 German Published, Non-Prosecuted Patent Application DE 43 32
346 A1 describes the impregnation of the expanded graphite
foils for the purpose of improving adhesion to elastomer
layers lying thereon. The viscosity of the epoxy resins used
in that case is 2100 to 2400 mPa·s.

10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
Published Japanese Patent Application JP 11 35 4136 A2
entitled "Fuel Cell, Separator for Fuel Cell, and Manufacture
Therefor" describes the production of expanded graphite in
sheet-like form. That partially recompressed expanded
graphite is subsequently comminuted (pulverized) and then
mixed selectively with resins, solvent-free epoxy resin, solid
epoxy resin, melamine resin, acrylic resin, phenolic resin,
polyamide resin, and the like. That mixture is subsequently
shaped. As will be shown later, that technique differs from
the bodies according to the present invention which have an
entirely different structure in that the resins are mixed into
an expanded graphite granulate.

The prior art set out above discloses various synthetic resin-
containing bodies produced by using expanded graphite as well
as processes for their production. That it is difficult to

produce high-quality, synthetic resin-containing graphite bodies from recompressed, expanded graphite is easy to see. All of the processes described have disadvantages, some of which are serious: if resins diluted by solvents and thus having lower viscosity are used during the impregnation, it is true that the impregnation is easier. However, the vapors from the, in most cases, readily volatile solvents cause serious problems during the impregnation itself, especially during subsequent process steps. In particular, as a result of the fact that they escape during the curing of the resins, they leave behind fine channels which raise the permeability of the bodies being produced. If an increased permeability can be neither tolerated nor is desired, a general problem exists. Furthermore, if the curing is not performed very slowly, i.e. is time-consuming, blisters and cracks are formed in the bodies, which lower their quality considerably.

The same applies to resin systems which release gases from condensation reactions during the curing. As a result of the fact that solvents or other gases and vapors escape, a residual porosity arises in the bodies. Attempts are now frequently made to eliminate the residual porosity by one or more additional impregnating operations. The attendant increase in expenditure is clear and the success is really limited. Additionally, solvent-containing resins above all always require measures to allow their safe handling and the

harmless removal or recovery of the solvents, which increases the expenditure even further. However, the solution through the addition of fibers penetrating the surfaces of the body may improve the impregnating properties of the body but does not eliminate the problems outlined for the use of solvent-containing resins releasing vapors or gases. In addition, one always has a product containing certain fibers, which is more expensive to produce.

Summary of the Invention:

It is accordingly an object of the invention to provide bodies formed of expanded or at least partially recompressed expanded graphite having a liquid-accessible pore system which is completely or partially filled with an uncured or partially or completely cured synthetic resin, a process for producing the bodies and sealing elements, fuel cell components and heat-conducting elements formed of the bodies, which overcome the hereinafore-mentioned disadvantages of the heretofore-known products and processes of this general type and in which the bodies do not contain any defects such as blisters or cracks that may be caused by reactions of the synthetic resin during the curing, in which the bodies are producible with comparatively little expenditure and in which the bodies are corrosion-resistant, electrically and thermally conductive and are from liquid-permeable to gas-tight, depending on the degree of compression.

With the foregoing and other objects in view there is provided, in accordance with the invention, a synthetic resin-impregnated body, comprising expanded or at least partially recompressed expanded graphite. The graphite contains or is impregnated with solvent-free, low-viscosity, storage-stable resin systems from the group of isocyanates with their co-reactants and/or epoxy resins or polymers obtained by curing the resin systems.

Therefore, the object of the invention is achieved with a body of the type mentioned at the outset, that is the primary product or the body obtained from the impregnated primary product, by at least partial compression containing either solvent-free and low-viscosity resin systems from the group of isocyanates and their co-reactants, which react to form isocyanurates, urethanes or polyurethanes, and/or of epoxides or cured resin systems produced from the aforementioned group. The resin systems enter into the body by impregnating the primary product with solvent-free, low-viscosity, storage-stable resin systems from the group of isocyanates and their co-reactants and/or of epoxides.

In order to eliminate the aforementioned disadvantages of solvent-containing resin systems and nevertheless achieve the advantages of resin systems having low viscosity, the

following special solvent-free resin systems are employed according to the invention presented herein:

1. Epoxy resin systems 1: These epoxy resin systems are characterized by the main components bisphenol-A-diglycidyl ether and methylhexahydrophthalic anhydride. According to the manufacturer's information, the former component constitutes more than 50% by weight and the latter component between 25 and 50% by weight of the total mixture. The mixtures contain a latent catalyst which has a crucial influence on the times when curing at elevated temperatures. Where possible, the resin system does not contain any catalyst. These resin systems have typically, at room temperature, a viscosity of 500 ± 100 mPa·s, and at a slightly elevated processing temperature of 50°C, typically a viscosity of about 70 ± 15 mPa·s.

2. Epoxy resin systems 2: These epoxy resin systems are characterized by the main components bisphenol-F-diglycidyl ether and methylhexahydrophthalic anhydride. According to the manufacturer's information, the former component constitutes more than 50% by weight and the latter component between 25 and 50% by weight of the total mixture. The mixtures additionally contain a latent catalyst which has a crucial influence on the times when curing at elevated temperatures. Where possible, the resin system does not contain any

catalyst. These resin systems have typically, at room temperature, a viscosity of about 200 ± 40 mPa·s, and at a slightly elevated processing temperature of 50°C typically a viscosity of about 40 ± 10 mPa·s.

5

3. Isocyanate resin systems: These resin systems are characterized by the main components diphenylmethane diisocyanate and bis(4,4'-glycidyoxyphenyl)propane. According to the manufacturer's information, the former component constitutes 75 to 85% by weight and the latter component between 15 and 25% by weight of this partial mixture. Such resin systems are referred to as modified isocyanurate resin systems. One hundred parts of this partial mixture are mixed with five to ten parts of a modified diphenylmethane diisocyanate, which acts as a latent catalyst. The partial mixtures of diphenylmethane diisocyanate and bis(4,4'-glycidyoxyphenyl)propane have, at room temperature, a viscosity of 40 ± 10 mPa·s, and the modified diphenylmethane diisocyanate has a viscosity of 20 ± 5 mPa·s. The stated total mixtures of one hundred parts of the partial mixture and five to ten parts of the modified diphenylmethane diisocyanate have viscosities in the range of from 25 to 40 mPa·s.

The low viscosities, which are essential to the invention, at the processing temperature of the impregnating resins from the three resin systems, ensure good and efficient impregnation of

the primary product. The polyadditions which take place during the curing do not give rise to any low-molecular-weight cleavage products, which could cause blistering or even cracks in the body. The testing of the resin systems is described in more detail in the examples.

On one hand, the (latent) catalysts bring about rapid curing reactions at high temperatures and, on the other hand, they bring about small changes in the chemical process of the resin systems at low temperatures, for instance room temperature, which are employed during the impregnation. These small changes can be proved with the aid of viscosity measurements.

Since the viscosities of the above-stated epoxy resin systems at room temperature are several hundred mPa·s, but the impregnating action is particularly advantageous at viscosities of below one hundred mPa·s, the impregnation with these resin systems is preferably carried out at slightly elevated temperatures in the range of from 40 to 60°C. These slightly elevated temperatures first of all bring about a drastic reduction of the viscosity, but then, in time, a slightly more rapid rise of the viscosity occurs than at room temperature. However, this does not have an adverse effect on the processing behavior of the resin systems. This is shown by the viscosities, which are given below by way of example, of the epoxy resin systems 2 with the component bisphenol-F-

diglycidyl ether. Throughout the investigation period, the resin system is maintained at 50°C:

a fresh resin mixture has approximately 35 mPa·s, after 6 days
5 it has approximately 60 mPa·s and after 12 days it has
approximately 150 mPa·s.

The resin system including isocyanate and the co-reactants,
which react in time to form isocyanurates, urethanes or
10 polyurethanes, is maintained at room temperature throughout
the investigation period and then shows the following
viscosities in mPa·s:

a fresh mixture has approximately 35, after three days it has
15 approximately 45, after 10 days it has approximately 50 and
after fourteen days it has approximately 60.

The small rate of the changes of the viscosity of the resin
systems at low temperatures, for instance room temperature for
20 isocyanates and their co-reactants and 50°C for epoxy resin
systems, and over a period of almost two weeks, which is
demonstrated by the viscosity measurements, will be referred
to hereinafter by the term "high storage stability".

25 It has been found that the storage stability of the resin
systems is not changed by the impregnating operation itself

and by the fact that the resin systems are present in the primary product after the impregnation. This has been shown indirectly, for example, by comparing curing times of pure resin systems and impregnated primary products. In both cases, the same curing times were measured and no differences were found in the quality of the cured resins.

Once the resin has been introduced into the primary product, it tends not to run out of the primary product again. Besides wetting behavior, the following considerations, in particular, are important:

1. During the impregnation, special techniques, such as vacuum or vacuum-pressure impregnation, for example, are employed. The filling of part of the existing pores is only made possible with the aid of such techniques. For example, filling resistances, such as the flow through narrow pore necks, are overcome in this way. Once the resin has been introduced in this way it cannot escape from the primary product again, without employing any special measures.

2. As explained above, the viscosity of the resins once introduced rises gradually. This rise is small at low temperatures (storage stability), but becomes very pronounced at higher temperatures, causing resins to gel. It is

virtually impossible for such partially gelled resins to escape from the impregnated body.

The expanded graphite used to produce the primary product is formed of fanned-out, wormlike structures in which very fine graphite platelets are joined together in the form of a defective accordion bellows. During the compression of the primary product, these platelets slide in and over one another. They become interlocked and thus come into contact again so as to no longer be able to be released without destruction. This gives rise in the primary product to a porous graphite framework or network which has good electrical as well as good thermal conductivity due to the good contacts between the graphite platelets. Since these properties are based on the framework function of the graphite in the primary product, they are not adversely affected by the impregnation with synthetic resin. They can even be further improved during a subsequent compression of the primary product impregnated with resin.

The primary product is permeated throughout by open pores which are interconnected in a variety of ways. As a result of this network of interconnected pores, the synthetic resin penetrates into the primary-product body during the impregnation and may even completely fill it under suitable conditions. The network of pores then becomes a network of

synthetic resin. Both networks, the graphite network and the pore/synthetic resin network, in combination result in the outstanding properties of the end products thus produced. It is also possible to control the level of properties of the end products by adjusting them in a specific manner. For example, on one hand, a primary-product body which has undergone little precompression and is thus highly porous has a lower electrical and thermal conductivity and a lower degree of anisotropy than a more highly compressed primary-product body.

On the other hand, it can take up more synthetic resin and has modified strength properties. This situation is reversed with greatly compressed primary-product bodies. After the impregnation and curing of the synthetic resin, they yield products with improved electrical and thermal conductivity, as well as good mechanical strengths. All of the bodies according to the invention which are described herein are highly impermeable to liquids and gases when their pore network has been completely filled with synthetic resin.

The product described in International Publication No. WO 98/09926 differs from that presented herein in that, in the former, a graphite foil is provided merely with a coating of plastics material for the purpose of reinforcement. The plastics material covers the surface and partially penetrates into the foil.

All of the known methods such as, for example, those described in Published Japanese Patent Application JP 60 24 2041 A2, corresponding to German Patent DE 35 12 867 C2, can be used for the impregnation of the primary-product bodies. It is preferable, however, to use immersion methods, in particular immersion methods with prior evacuation of the vessel containing the primary-product body and flooding of the evacuated vessel with the synthetic resin. Where appropriate, the vessel is also subjected to a gas pressure after it has been flooded with the synthetic resin. If the primary-product body is to be merely impregnated close to the surface or is to be partially impregnated, the impregnating period is shortened or the surfaces from which the impregnation is to start are suitably coated or sprayed with synthetic resin or the body is only partially immersed. Following that treatment, the excess resin is removed from the surface.

An essential aspect of the present invention is efficient, damage-free impregnation and curing. The rapid blister-free and crack-free curing made possible by virtue of the polyaddition reactions has been discussed above. Efficient impregnation depends essentially on the viscosity of the resin systems. This is shown by the following comparison for the vacuum impregnation at 50°C of a primary product of the same type having the following features: flexible graphite foil with a bulk density of 1.0 g/cm³ and a thickness of 1.0 mm:

Resin system	Viscosity (mPa·s)	Impregnating period (h)	Resin uptake (% by weight)
Epoxy resin systems 2	40	5	15
Epoxy resin systems 1	70	5	8

It is thus possible to introduce about twice the amount of resin into the primary product with the low-viscosity epoxy resin systems 2 than with the higher-viscosity resin systems 1, for otherwise identical boundary conditions and within the same period. If the intention is to introduce merely the smaller amount of resin indicated in the table, this is achieved in an impregnation with the low-viscosity epoxy resin systems 2 in only half the impregnating time as compared with the epoxy resin systems 1. A rapid impregnating operation is of great importance for efficient and cost-effective manufacture.

The primary product can take up an amount of up to 100% of its own weight of resin, depending on the degree of compression of the primary product and the open pore volume which is conditional thereon. If, however, a high electrical conductivity is desired of the end product, it is expedient to start with a primary-product body which has undergone greater precompression and has a lower open pore volume and can then, for example, take up only 20% by weight of resin based on its

own weight. After the curing of the resin, such a body can be highly impermeable to liquids and gases, as seen in the examples, and has good strength properties.

5 Particularly epoxy resins, as well as isocyanate resins with their co-reactants, are known for the fact that their curing reactions start gradually and can also be slowed down again with suitable temperature control. In the case of epoxy and isocyanate resins it is thus possible to preserve a partially
10 reacted, gel-like state, which is also called a "B state" in technical terminology.

In the B state the synthetic resins have a higher viscosity, but can still be shaped. This B state is advantageously used
15 within the framework of the present invention. Thus, for example, resins or primary-product bodies or parts impregnated with the resins can be stored over a prolonged period of time or transported during this time. Further steps for the intermediate treatment of the impregnated bodies are possible.

20 For example, such bodies can be machined, e.g. cut, or a number of them can be laminated together to form a stack. However, the fact that the primary-product bodies containing a resin in the B state can be brought into their final shape in suitable shaping configurations and molds is of particular
25 importance for the invention. During the accompanying pressure treatment, the gel-like resins are, in practice, no

longer squeezed out of the pore system of the body as is the case in an uncontrollable manner with resins which cannot be converted into a gel state. After the shaping, the resin part of the resin-impregnated primary-product body is cured. This is carried out, for example, in a curing chamber at the prescribed temperatures and times.

If the shaping configurations are equipped with apparatus for curing the resins, the shaping operation can even be combined with the curing of the resin in the body. The desired end product is thus obtained directly in an advantageous manner. Such a procedure is interesting particularly when relatively large series of components or bodies are to be produced by using the techniques described above and a number of process steps are to be efficiently combined in the manner outlined. It is convenient for the impregnated primary product, which is generally in the form of a semifinished product or blank, to be put into a mold which is already hot and for the mold to be closed for this purpose. The semifinished product thereby takes on the desired geometry, is simultaneously thoroughly heated and cures completely.

The curing takes place at 120 to 180°C with latently catalyzed resin systems from the group of isocyanates and their co-reactants or/and from the group of the epoxides. A curing time of two hours is sufficient with such systems if the

temperatures lie at the lower end of the specified temperature range. If a relatively high temperature at the upper end of the specified temperature range is chosen, a curing time of fifteen minutes is sufficient.

5

When resin systems from the group of isocyanates and their co-reactants or/and from the group of epoxides are not latently catalyzed, curing is effected in the same temperature range of 120 to 180°C, but curing times of twenty-four to forty hours are then necessary. If a relatively high temperature at the upper end of the specified temperature range is chosen, a curing time of twenty-four hours is sufficient. If the temperatures lie at the lower end of the specified temperature range, curing for up to forty hours is required.

15

A relatively wide variety of graphites based on synthetic production and natural occurrence exists, both types being mentioned in U.S. Patent No. 3,404,061. Only natural graphite will be discussed hereinbelow, with the graphite being present as raw material in the bodies described herein.

20

Natural graphite is obtained by mining and is separated from the gangue rock with considerable effort. Nevertheless, very small amounts of rock also remain, attached to the natural graphite flakes or having intergrown into the flakes. Those "foreign constituents" are characteristic of every source of

25

natural graphite and can also be specified as an ash value. A method for determining such ash values is described in DIN (German Industrial Standard) 51 903 under the title "Testing of Carbon Materials - Determination of the Ash Value".

5

In view of the end uses of the synthetic resin-containing graphite bodies according to the invention, the ash values and ash composition of the graphite that is present are quite important.

b6
b7C 10

If such bodies are employed, for example as inherently corrosion-resistant seals in installations subjected to corrosive media, certain ash constituents together with the corrosive medium may result in pitting in the corrosion-resistant seals adjoining flanges or bushes of stuffing-box packings and eventually lead to the failure thereof.

Another example of a possible adverse effect of too high an ash value or an unfavorable ash composition of the graphite in a synthetic resin-containing body according to the invention is found in fuel cell technology. Thus, for example, bipolar plates of proton exchange membrane fuel cells can be produced from the material according to the invention. If such a plate now has too high an ash content, some of the harmful ash constituents may be released from the plate during the operation of the fuel cell and poison the sensitive catalysts

located close to the surfaces of the bipolar plate, resulting in a premature loss of power of the cell.

Due to the potential adverse effects of an excessively high ash content, the ash content of the graphite used to produce the bodies according to the invention is 4 per cent by weight and less, preferably less than 2 per cent by weight and in special cases no more than 0.15 per cent by weight.

10 It may be convenient to strengthen the body according to the invention with fillers, with the selection of the fillers having to be matched to the application (e.g. a fuel cell). Fillers may be electrically conductive materials closely related to expanded natural graphite, such as, for example, materials from the group consisting of naturally occurring 15 flake graphites, synthetically produced electrographites, carbon blacks or carbons, and graphite or carbon fibers. Furthermore, use may be made of silicon carbide in granular or fibrous form or even electrically non-conductive ceramic or 20 mineral fillers in granular, platelike or fibrous form, such as silicates, carbonates, sulfates, oxides, glasses or selected mixtures thereof.

The bodies according to the invention can be used wherever 25 electrically and thermally conductive components of low weight together with good corrosion resistance are required. Further

properties which are essential for various applications are low ash values and relatively high impermeability. The bodies according to the invention are used in particular for components of fuel cells, for seals and for heat-conducting elements, for example for conducting away the excess heat from integrated circuits.

Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is described herein as embodied in impregnated bodies made of expanded graphite, a process for producing such bodies and sealing elements, fuel cell components and heat-conducting elements formed of the bodies, it is nevertheless not intended to be limited to the details given, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying examples. In addition, methods for obtaining

data on electrical properties and gas-tightness for the examples are dealt with now.

In order to determine gas-tightness, a resin-impregnated
5 graphite body was pressed as a separating plate (test specimen) between two chambers of a testing apparatus. A constantly maintained helium gas pressure of 2 bar absolute prevailed in a first chamber. A metal grid which mechanically supported the test specimen was disposed in a second chamber.

10 In addition, this chamber was connected at ambient pressure to a liquid-filled burette, such as that which is used, for example, in the leakage measurement of flat seals according to DIN 3535.

15 The helium gas emerging from the first chamber and diffusing through the test specimen was collected in the second chamber and measured by displacement of the liquid in the burette. It was thus possible to determine the volume of the helium gas which diffused through the sample per unit of time. While
20 taking the helium density and the testing area into account, a leakage rate was ascertained which is specified by a unit $\text{mg}/(\text{m}^2 \cdot \text{s})$.

The material composite of partially recompressed expanded
25 graphite and synthetic resin has anisotropic properties, i.e. the individual graphite platelets of the expanded graphite

have a preferred orientation due to the production technique. For example, the electrical resistance parallel to this preferred orientation is low and perpendicularly thereto it is higher. In the present case, the cured shaped bodies according to the invention were characterized comparatively by measuring the electrical resistance perpendicularly to the preferred orientation of the graphite layers. For this purpose, the body was clamped between two gold-plated electrodes with a diameter of 50 mm, with defined and in each case identical surface pressure. The electrical resistances R established with the aid of a device (Resistomat 2318) from the firm Burster (Gernsbach, Germany) are specified by a magnitude [$\text{m}\Omega$] hereinbelow.

15 Example 1

Plates made of partially recompressed expanded graphite (primary-product plates) with an ash value of less than 2% by weight, a thickness of 1 mm and a bulk density of 1.0 g/cm^3 are subjected to a vacuum impregnation treatment with latently catalyzed epoxy resin systems. Epoxy resin systems 1 and 2 were used, and came from the firm Bakelite (Duisburg, Germany). Epoxy resin systems 1 bear the trade name Rütapox VE 4834 and had a viscosity of approximately $70 \text{ mPa}\cdot\text{s}$ at 50°C . Epoxy resin systems 2 bear the trade name Rütapox M4-1158-CK and had a viscosity of approximately $40 \text{ mPa}\cdot\text{s}$ at 50°C .

The primary-product plates were introduced into an evacuable receptacle and heated to 50°C. After application of a vacuum (approximately 10 mbar residual pressure), the resin system which had been previously heated to 50°C was sucked into the
5 receptacle, so that the primary-product plates were completely surrounded by resin. After the impregnating period indicated in Table 1, the now impregnated plates were taken out of the bath and, after the resin adhering to the surface had been wiped off, were weighed. The impregnated plates were
10 subsequently cured at 150°C in a preheated circulating-air oven for 30 minutes. Despite this shock curing, the plates showed no blisters or cracks at all. The values determined for the impregnating experiments with the epoxy resin systems 1 and 2 and comparative values for a non-impregnated primary-
15 product plate of the same type are summarized in Table 1. The resin system used, the impregnating period, the resin content of the impregnated body determined after the curing, its electrical volume resistance R , measured perpendicularly to the preferred orientation of the graphite platelets, and the
20 helium permeability λ measured perpendicularly to the preferred orientation of the graphite platelets, are shown.

	Impreg- nating period[h]	Viscosity [mPa·s]	Resin content [%]	R [mΩ]	λ [mg/ (m ² ·s)]
Epoxy resin systems 1	10	70	15	0.52	0.07
Epoxy resin systems 2	5	40	14.6	0.39	0.04
Non- impreg- nated primary product plate	-	-	0	0.28	0.32

Table 1:

Comparison of the volume resistance R and the helium permeability λ of an epoxy resin-impregnated primary product (thickness 1 mm, bulk density 1.0 g/cm³) with a non-impregnated primary product (thickness 1 mm, bulk density 1.0 g/cm³).

As can be seen in Table 1, virtually the same resin content of approximately 15% is achieved after only 5 hours with the low-viscosity epoxy resin systems 2 based on bisphenol-F-diglycidyl ether as with the higher-viscosity epoxy resin systems 1 based on bisphenol-A-diglycidyl ether after an impregnating period of ten hours.

A comparison of the material composite and the non-impregnated primary product shows the following: as a result of the resin

impregnation, the helium permeability of the bodies is reduced by a factor of five and eight, respectively. The volume resistance is only slightly increased by the impregnating treatment.

5

Example 2

In this example, the epoxy resin systems 1 were used without a latent catalyst. The primary-product plate employed was of the same type as that employed in Example 1. Similarly, the impregnating conditions were the same as those in Example 1 with regard to the procedure, time and temperature.

The difference, however, is the curing behavior of the resins. In order to cure the impregnated primary-product plate, a curing period of 24 h at 150°C is required in this example.

The epoxy resin systems 1 have a high storage stability at 50°C without a latent catalyst. Starting from 30 to 70 mPa·s, the viscosity rises to from 65 to 90 mPa·s at 50°C after four weeks' storage. Resin systems with a latent catalyst exhibit a rise in viscosity to over 100 mPa·s after only approximately 1 week.

Example 3

In this example, the following plates made of partially recompressed expanded graphite (primary-product plates) were

impregnated with an isocyanate resin system by immersion at room temperature.

	Type of primary product plate	Thickness [mm]	Bulk density [g/cm ³]
Example 3a	F02510C	0.25	1.0
Example 3b	L10010C	1.0	1.0
Example 3c	L20010C	2.0	1.0
Example 3d	L40005C	4.0	0.5

5 Table 2:

Plates made of partially recompressed expanded graphite (primary-product plates) used for the impregnation with an isocyanate resin system.

10 The isocyanate resin system used had the following composition:

100 parts of Blendur VP KU 3-4520

10 parts of Blendur VP PU 90IK06

15 Both resin components came from the firm Rhein Chemie Rheinland GmbH (Mannheim, Germany). Blendur VP KU 3-4520 is formed of 75 - 85% by weight of diphenylmethane diisocyanate and 15 - 25% by weight of bis(4,4'-glycidylphenoxyphenyl)propane. Blendur VP PU 90IK06 is the latent catalyst which is formed

predominantly of modified diphenylmethane diisocyanate,
according to the manufacturer's information.

The various primary-product plates were completely immersed in
the resin system. After an immersion time of 10 hours, the
plates were removed from the resin bath and the resin adhering
to the surface was wiped off. The impregnated plates were
then put into a preheated circulating-air oven and cured at
160°C for 30 minutes. After this shock curing, the plates had
no blisters or cracks at all.

The resin contents of the primary-product plates listed as
well as selected material properties are shown in Table 3 in
comparison with non-impregnated primary-product plates.

	Type of primary- product plate	Resin content [%]	R [mΩ]	λ [mg/ (m ² ·s)]
Example 3a	F02510C	29.4	0.24	< 0.0015
Example 3b	L10010C	16.0	0.43	0.028
Example 3c	L20010C	11.4	0.57	-
Example 3d	L40005C	38.9	0.85	-
Example 3a'	F02510C	0	< 0.10	1.50
Example 3b'	L10010C	0	0.28	0.32

Table 3:

A comparison of the volume resistance R and the helium permeability λ of cured, impregnated primary product (varying thickness and bulk density) with non-impregnated primary product (of likewise varying thickness and bulk density); Examples 3a and 3a' as well as Examples 3b and 3b' in particular, are to be compared.

As is evident from Table 3, the resin uptake or absorption varies depending on the bulk density of the primary product, with a low bulk density resulting in a high resin uptake or absorption. The impregnated primary product may contain up to 40% resin. The helium permeability of the impregnated plates is lower by more than a factor of ten in comparison with non-impregnated plates. The electrical volume resistance is only moderately increased by the impregnating treatment.

Example 4

This exemplary embodiment was concerned with the impregnation of a primary-product plate with the epoxy resin systems without a latent catalyst, and the precuring and shaping thereof after the impregnation with synthetic resin.

The primary-product plate made of partially recompressed expanded graphite had a thickness of 2.7 mm and a bulk density of 0.65 g/cm³. The ash value of the graphite was less than or

equal to 0.15% by weight. The vacuum impregnation process was performed at 50°C in accordance with Example 1. After an impregnating period of two hours, the now impregnated plate was taken out of the bath and, after the resin adhering to the surface had been wiped off, weighed. The resin content of the uncured plate was 16%. Subsequently, the plate was put into a circulating-air oven at 150°C for a period of 20 hours and the resin present in the body was converted into the B state. In the B state the resin present was partially gelled and the impregnated plate was still soft and flexible. It was placed in a pressing die preheated to 180°, pressed into the mold for a period of one hour and, as a result, was further compressed. The plate took on the geometry of the pressing mold which was coated with anti-sticking agent. After the pressing mold had been opened, the impregnated and now partially cured shaped body had sufficient stability for it to be removed from the mold without destruction. After a further heat treatment of the shaped body for 12 hours at 150°C, the resin was completely cured. The cured shaped body showed no cracks or blisters at all. Furthermore, none of the resin in the B state was pressed out of the impregnated body by the pressing, so that a continuous resin layer did not accumulate at the surface of the shaped body. As has been shown in practice, excess resin not previously converted into the B state is squeezed out of the body during the pressing in a shaping apparatus. This squeezed-out resin can form a resin skin on

the outer surfaces of the body which has an electrically and thermally insulating action and may be undesirable, depending on the intended use of the product.

5 Example 5

The primary-product plate was of the same type as in Example 4 and had a thickness of 2.7 mm and a bulk density of 0.65 g/cm³. This primary-product plate was immersed in an impregnating resin at room temperature for one hour. This resin was formed of 95 parts by weight of Blendur VP KU 3-4520 and 5 parts by weight of Blendur VP PU 90IK06. (Both components were also used in Example 3 with a slightly different composition). After the impregnation, the resin content of the plate was 15% by weight. The impregnated plate was heated at 150°C for a period of nine minutes, in the course of which the resin was converted into the B state and partially gelled. This still-warm plate was subsequently placed in the molding die, which was preheated to 150°C, and was pressed into the mold. The pressing mold coated with anti-sticking agent remained closed for five minutes and was then opened, and the body which was cured in the meantime was removed from the pressing mold.

In this example too, none of the resin in the B state was squeezed out of the impregnated body by the pressing, so that a continuous resin layer did not accumulate at the surface of

the shaped body and the shaped body showed no electrically insulating action at all in the surface region.

Example 6 (comparison, prior art)

- 5 In this example, a solvent-containing epoxy resin system was deliberately used for the impregnation. The following composition was chosen for the resin system:

75 parts of epoxy resin systems 2 (see Example 1) with
the main components bisphenol-F-diglycidyl ether and
methylhexahydrophthalic anhydride without a latent
catalyst, and
25 parts of 2-butanone (solvent).

- 15 The viscosity of this solvent-containing resin system was 15 mPa·s at room temperature. The primary product had a bulk density of 1.0 g/cm³, a plate thickness of 1 mm and an ash value of less than 2% by weight. The vacuum impregnation was carried out as in Example 1, but at room temperature rather
20 than at 50°C. After an impregnating period of 6.5 hours, the now impregnated plate was taken out of the bath and, after the resin adhering to the surface had been wiped off, weighed. The resin content was 23% by weight in the uncured state.

- 25 The impregnated plate was then put into a preheated circulating-air oven with a temperature of 150°C and after a

curing period of 30 minutes removed from the oven. The plate was covered in blisters of varying sizes and was completely unusable! Neither a volume resistance nor a helium permeability could be determined thereon.

5

The cured plate covered in blisters showed a marked decrease in weight as compared with the freshly impregnated state. The resin content had dropped as a result of the curing treatment from 23% in the uncured state to 17.8% in the cured state.

10 This was not observed on the samples of Examples 1 to 5, in which solvent-free resin systems had been employed. The loss in weight in Example 6 was attributable to the evaporation of the solvent. The blisters were forced up because the evaporation of the solvent took place not only at the surface of the impregnated body but also in the interior of the body and escape was hindered by the material layers lying above.

If a plate impregnated with a solvent-containing resin system were pressed in a molding die and cured, as described in
20 Example 4 for solvent-free resin systems, the difficulties would only be compounded, because the released solvent vapors would not be able to escape unhindered and consequently defects and blisters would be formed in the body to an increased extent and in an uncontrollable manner. Production
25 of a shaped body impregnated with a solvent-containing resin by further compression in a pressing apparatus and subsequent

curing is not possible in acceptable production times without a massive reduction in quality of the desired end product.

Comparing Example 6 with Examples 1 to 5 clearly shows the progress which has been achieved with the solution according to the invention.

Besides these above-mentioned examples, a multiplicity of further bodies and procedures can be realized according to the teaching of the present invention. Accordingly, the invention is not restricted to the embodiments illustrated in the examples. Variants which are not shown but which a person skilled in the art could produce due to the information offered by this disclosure are therefore also to be included in this patent application.